UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 974

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER October 15, 1921

DIRECTIONS FOR BLUEBERRY CULTURE, 1921

By

FREDERICK V. COVILLE, Botanist

CONTENTS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 974

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER October 15, 1921

DIRECTIONS FOR BLUEBERRY CULTURE, 1921.[1]

By FREDERICK V. COVILLE, *Botanist.*

CONTENTS.

EARLY EXPERIMENTS WITH BLUEBERRIES.

The experiments which have led to the present publication were begun in 1906. The work of the first four years resulted in a publication entitled "Experiments in Blueberry Culture," issued in 1910.[2] This work was widely distributed, and a copy came into the hands of Miss Elizabeth C. White, New Lisbon, N. J. Miss White at once perceived the significance of the experiments and the importance of testing their application to the waste lands surrounding her father's cranberry bogs. An informal agreement of cooperation resulted. In 1913 this was replaced by a formal contract, the object of which was to provide suitable conditions for a field test of the blueberry hybrids produced in the course of the experiments at Washington, D. C. The location of the testing plantation is at Whitesbog, 4 miles east of Browns Mills, N. J., in the sandy, peaty, acid soil of the pine barrens. Up to the present time 16 acres have been planted with 27,000 different hybrid seedlings. Thus far, about 18,000 of these

[1] Revised by the writer from "Directions for Blueberry Culture, 1916," which was published as United States Department of Agriculture Bulletin 334.

[2] The publication mentioned, issued as Bulletin No. 193 of the Bureau of Plant Industry, gave a detailed account of the principles of blueberry culture, including the soil requirements and peculiarities of nutrition of the blueberry plant and the details of the growing of seedlings. It contained 100 pages of text, with 18 plates and 31 text figures. It was reissued in 1911. Both editions are now out of print.

53319°—21—Bull. 974——1

hybrids have fruited and four of them have been selected and approved as worthy of introduction into agriculture. Propagation material from these four hybrids has been placed in the hands of nurserymen for commercial propagation.

Miss White has also brought together at Whitesbog a very remarkable collection of selected wild blueberry plants. Several of these have been used as breeding stocks in the blueberry development work carried on by the department.

In the present bulletin are included such results of the experiments and experience at Washington, Whitesbog, and other points as constitute a brief practical guide for persons desiring to take up blueberry culture.

SPECIAL REQUIREMENTS.

Success in blueberry culture rests especially on the recognition of two peculiarities in the nutrition of these plants: (1) Their requirement of an acid soil; (2) their possession of a root fungus that appears to have the beneficial function of supplying them with nitrogen.

If blueberries are planted in a soil with an alkaline or neutral reaction, such as the ordinary rich garden or fertile field, it is useless to expect their successful growth. In such a situation they become feeble and finally die. Blueberries require an acid soil, and they thrive best in that particular type of acid soil which consists of a mixture of sand and peat.[3] (Pl. I.)

Good aeration of the soil is another essential. It is commonly but erroneously supposed that the highbush or swamp blueberry (*Vaccinium corymbosum*), the species chiefly desirable for cultivation, grows best in a permanently wet soil. It is to be observed, however, that the wild plants of the swamps occupy situations which, though perhaps submerged in winter and spring, are exposed to the air during the root-forming period of summer and autumn; or, when growing in permanently submerged places, they stand on a hummock or in a cushion of moss which rises above the summer water level and within which the feeding roots of the bush are closely interlaced. In actual culture, moreover, it has been found that the swamp blueberry does not thrive in a permanently wet or soggy soil.

Although some species of Vaccinium, such as the common lowbush blueberry of the northeastern United States, *Vaccinium angustifolium* (called *V. pennsylvanicum* by some authors), grow and

[3] The degree of soil acidity best suited to blueberries is about specific acidity 100, corresponding to a hydrogen ion concentration, $P_H=5$. See a paper by Edgar T. Wherry, "Soil Acidity and a Field Method for Its Measurement," published in the technical journal Ecology, vol. 1, pp. 160 to 173, July, 1920, with a colored plate. The same subject is treated more fully by Dr. Wherry in the general appendix to the Smithsonian Report for 1920, also with a colored plate, under the title "Soil Acidity—Its Nature, Measurement, and Relation to Plant Distribution."

fruit abundantly in sandy uplands that are subject to drought, the swamp blueberry grows best in soils naturally or artificially supplied with adequate moisture.

These, then, are the three fundamental requirements of successful blueberry culture: (1) An acid soil, especially one composed of peat and sand; (2) good drainage and thorough aeration of the surface soil; and (3) permanent but moderate soil moisture. Under such conditions the beneficial root fungus which is believed to be essential to the nutrition of the plant need give the cultivator no concern, for even if the necessary fungus were wholly lacking in the soil of the new plantation each healthy bush set out in it would bring its own supply of soil-inoculation material.

Next in importance to soil conditions is a convenient location with reference to a good market. The berries should reach their destination without delay, preferably early in the morning following the day of picking. To secure the best prices they should also reach the market before the height of the main wild-blueberry season. A situation to the south of the great areas of wild blueberries in northern New England, Canada, and northern Michigan is therefore desirable. One of the most promising districts for blueberry culture is the cranberry region of New Jersey, for there an ideal soil occurs in conjunction with an early-maturing season and excellent shipping facilities to the markets of Philadelphia and New York.

Situations liable to late spring freezes, such as the bottoms of valleys, should be avoided, for although the blueberry plant itself is seldom permanently injured by such a freeze its crop of fruit may be destroyed.

It has been observed that in or around bodies of water, such as cranberry reservoirs or cranberry bogs temporarily flooded to prevent frost or insect injury, the wild bushes often produce normal crops of blueberries in seasons in which the wild crop of upland blueberries has been destroyed by late spring freezes. Proximity to such bodies of water is evidently advantageous.

In regions subject to very low winter temperatures a blanket of snow sufficiently deep to cover the bushes often protects them completely, when twigs not covered by the snow are winterkilled. In the very cold February of 1918 the fruiting twigs of lowbush hybrids at Whitesbog, N. J., unprotected by snow, were killed by temperatures of about 12° below zero F. Both parents of these hybrids were uninjured at Greenfield, N. H., where the temperature went down to 30° below zero, but the plants there were covered with deep snow. Another observation made in the same season on Crotched Mountain, N. H., merits attention in this connection. Wild-blueberry bushes 6 to 7 feet high, the tops of which projected through

the snow, bore no fruit on the exposed tops in the following summer, while the sides and bases of the same bushes, which had been covered with snow, yielded the usual abundance of berries. The dead fruit buds still remained on the winterkilled twig tips at the exposed tops of the bushes.

IMPORTANCE OF SUPERIOR VARIETIES.

In the southern United States and in the Middle West blueberries are not ordinarily distinguished from huckleberries, but in New England the distinction is very clearly drawn. The name huckleberry is there restricted to plants of the genus Gaylussacia, the berries of which contain 10 large seeds with bony coverings like minute peach pits, which crackle between the teeth. The name blueberry is applied in New England to the various species of the genus Vaccinium, in which the seeds, though numerous, are so small that they are barely noticeable when the berries are eaten. It is probable that the comparatively low estimation in which this fruit is held in the South is largely due to the lack of a distinctive popular name and the consequent confusion of the delicious small-seeded southern Vacciniums with the coarse large-seeded Gaylussacias. It is the culture of the small-seeded blueberries only, as distinguished from the large-seeded huckleberries, that is here advocated.

From the market standpoint the features of superiority in a blueberry are sweetness and excellence of flavor; large size; light-blue color, due to the presence of a dense bloom over the dark-purple or almost black skin; "dryness," or freedom from superficial moisture, especially the fermenting juice of broken berries; and plumpness—that is, freedom from the withered or wrinkled appearance that the berries begin to acquire several days after picking.

Although blueberry plantations may be formed by the transplanting of unselected wild bushes or by the growing of chance seedlings, neither of these courses is advocated, because neither would result in the production of fruit of an especially superior quality. Seedling plants, even from the largest berried wild plants, produce small berries as often as large ones. The cultivator should begin with the purchase of a few plants of selected hybrid varieties or by the transplanting of the best wild bushes, selected when in fruit for the size, color, flavor, and earliness of the berry and the vigor and productiveness of the bush. These he should propagate by layering, by division, and by cuttings. Through a combination of these methods, a valuable old plant can often be multiplied by several hundred at one propagation, the fruit of the progeny retaining all the characteristics of the parent.

In making selections among wild bushes it is an excellent plan to preserve for future reference about a dozen of the largest berries in

a tightly stoppered wide-mouthed bottle containing a mixture of 1 part of formalin, or 40 per cent formaldehyde, to 15 parts of water. Each bottle should contain berries from only a single bush or, in the case of a plant that spreads by the root, from a single patch. Care should be taken not to rub the delicate "bloom" from the berries. A small twig bearing two or three leaves, from the same plant from which the berries were taken, should also be placed in the bottle. The Department of Agriculture would be glad to receive such samples and identify them for the sender. Some of the bushes thus located might prove to be of value in the blueberry breeding work of the department.

Great interest has developed recently in Florida on the subject of blueberry culture. Extravagant and misleading statements have been published and thousands of ordinary wild bushes have been sold at high prices, the purchasers being led to believe that the plants were of specially selected or adapted varieties. One company, located near Tampa, published as the frontispiece of a blueberry advertising pamphlet a natural-size illustration of a quart box of one of the United States Department of Agriculture selected hybrids, without designating it as such. The reader of the pamphlet would naturally believe that the bushes the firm was selling would produce such berries as were shown in the illustration. The real success of a single blueberry plantation near Crestview, in northwestern Florida, set with selected plants from the near-by woods, is chiefly responsible for the present wave of blueberry exploitation in that State. The best advice that can be given at present to those desiring to experiment with blueberry culture in Florida is to make certain that any plants they buy are as represented by the seller, to be sure that alleged improved varieties are not in reality ordinary wild blueberries, perhaps inferior to wild bushes that the purchaser might find in his own neighborhood by careful search. The selected hybrids described in this bulletin are of northern parentage and probably will not thrive in Florida because Florida winters are not sufficiently cold to give these plants the chilling they require in winter.[4] The United States Department of Agriculture has already begun the breeding of improved blueberries from species native in Florida, but it greatly desires better southern breeding stocks than it now possesses. Those interested in the advancement of blueberry culture in Florida are especially urged to make selections among their wild blueberries in accordance with the general directions given in the two preceding paragraphs.

[4] For an account of the experiments that led to this conclusion, see "The Influence of Cold in Stimulating the Growth of Plants," published in the Journal of Agricultural Research for October 15, 1920, vol. 20, pp. 151 to 160, with 16 plates.

PROPAGATION.

While grafting or budding is almost indispensable in experimental work with blueberries, bushes propagated by these methods are not suitable for permanent commercial plantations, because such bushes are continually sending up new and undesirable shoots from the stock. Budding, however, is the best known means of producing a large quantity of cutting wood from a valuable selected blueberry hybrid. It is useful also in testing the quality of a new variety, for a budded blueberry when properly handled comes into bearing two years from the time of budding and doubtless will continue to yield for several years, until the budded stem becomes old and decrepit.

BUDDING.

The best season for budding the blueberry is from the middle of July to the middle of August. The ordinary method of shield budding,[5] with a T-shaped cut and dry and unwaxed raffia wrapping, has proved the most successful of all the methods tried. (Pl. II.) In selecting budwood, attention should be paid to the following points: A bud forms at the base of each leaf; at first the scales covering the bud are green; when they are a little older they become straw colored, and later brown. When the buds have reached this brown stage they are of the proper age for use. All three stages may occur at the same time on a single branch, and in such a case the upper part of the branch should be discarded. A bud is more easily handled if the tiny leafstalk is left attached to it. Provision for this is easily made by cutting off the blades, but not the stalks, of the leaves when the branches that are to be used for budwood are removed from the parent bush. Care should be taken to discard the large fat flowering buds that occur toward the ends of the branches. In most blueberry plants, however, these flowering buds do not develop until after the budding season.

When blueberry buds are to be inserted the same day on which the budwood is cut, the sticks require no other treatment than to be kept in the shade in the folds of a moist clean towel. The budwood is easily ruined, however, by continued subjection to the high temperatures prevalent at the midsummer budding season. Any budwood that has been cut should therefore be kept on ice at night or at any other time when it is not in actual use.

In carrying blueberry budwood long distances, excellent results have been secured by the use of a thermos bottle. The bottle, opened, and the budwood, in clean moist wrappings and with additional moist packing material, should be kept on ice for several hours

[5] This and other methods of budding are described in Farmers' Bulletin 157, "The Propagation of Plants," by L. C. Corbett.

until thoroughly chilled. Just before the journey is to begin the chilled budwood and packing material is placed in the bottle and the bottle closed. Immediately on arrival at its destination the bottle should be opened and the contents kept chilled in an ice box until used. By this method blueberry budwood has been kept in perfect condition for more than a week, and probably that period can be much prolonged.

The best wood on which to bud is the lower portion of vigorous basal shoots of the season, especially those from plants that were cut to the stump in the preceding winter or early spring. On such shoots the bark can be lifted with ease much later in the season than on older stems. In taking the bud from the stick of budwood the cut is made just deep enough to leave a thin layer of wood attached to the middle of the bud slice. The raffia should be tied rather tightly, so that the juice almost begins to be squeezed from the soft bark. Special care should be taken that the raffia wrapping does not become wet and fermentation ensue between the raw surfaces of bud and stock. Plants budded in a greenhouse should therefore be watered on the surface of the ground, not on the foliage. In the case of outdoor plants liable to be wet by the rain the bud wrappings can be effectually protected by the use of a piece of strong paraffined paper about 6 inches square made into a little cone about the stem just above the bud wrappings and securely tied there with raffia, the lower part of the cone hanging down around the stem like a little skirt, keeping the rain away from the bud and its wrappings. (Pl. III.)

Union of the bud with the stock should take place in two to three weeks. As soon as the budded stem has increased in diameter sufficiently to cause pronounced choking by the raffia, all the wrappings should be removed. Otherwise the choked stem may be broken off by the wind. If choking does not occur the wrapping may be allowed to remain until spring.

Before growth begins in the following spring the stem is cut off above the inserted bud, which is still dormant. Only the inserted bud should be allowed to grow, all other growth from the stock being promptly rubbed off as soon as it starts. (Pl. IV.) Under this treatment the shoot from the inserted bud is very succulent and heavy, and a wind easily breaks it from the stock, but slice and all. To prevent this, the growing shoot, beginning at a length of 6 to 8 inches, should be tied at intervals to a strong stake.

In greenhouse experiments a growth of more than 8 feet has been obtained in the first season from an inserted bud on a vigorous plant, and when the shoot has been made to branch repeatedly by removing the growing tips (Pl. V) as many as 70 cuttings have

been produced the first year from a single valuable bud. In field practice at Whitesbog about 10 cuttings on the average are produced the first year from a single inserted bud, and in individual cases as many as 30 have been produced. (Pl. VI.)

STUMPING.

The easiest way to propagate the swamp blueberry is by a special process of layering called "stumping." The directions are as follows:

(1) In late fall, winter, or spring, preferably in early spring before the buds have begun to push, cut off at the surface of the ground either the whole of the plant or as many of the stems as it is desired to devote to this method of propagation. The stems that are cut off are discarded, or they may be used for cuttings, as described under "Tubering" or "Winter cuttings."

(2) Cover the stumps to the depth of 2 to 3 inches with a mixture of clean sand and sifted peat, two to four parts of sand to one of peat by bulk. A rough box or frame may be built on the ground to keep the sand bed in place.

(3) Care must be taken that the sand bed be not allowed to become dry except at the surface during the summer.

(4) The new growth from the stumps, which without the sand would consist of stems merely, is transformed in working its way through the sand bed into scaly, erect or nearly erect rootstocks which on reaching the surface of the sand continue their development into leafy shoots. (Pl. VII.) Although roots are formed only sparingly on the covered bases of stems, they develop abundantly during spring and early summer on these artificially produced rootstocks, and by the end of autumn all the shoots should be well rooted at the base. They should remain in place in the sand bed till late winter or early spring, undisturbed and exposed to outdoor freezing temperatures; but the sand should be mulched with leaves, preferably those of red oaks, to prevent heaving in freezing weather and to maintain an acid condition of the soil.

(5) Early in the following spring, before the buds have begun to push, open the bed and sever each well-rooted shoot carefully from the stump. Discard the upper portion of the shoot, making the cut at such a point as to leave on the basal portion about three buds above the former level of the sand bed. If the cut at the basal end of the rooted shoot is not smooth or the wood is cracked, recut the surface with a sharp thin-bladed knife. The discarded upper portion of the shoot may be used for winter cuttings, as described on pages 12 to 14.

(6) Set the rooted shoots in a coldframe or a cool greenhouse in a soil mixture consisting of two parts, by bulk, of rotted upland peat and one part of clean sand. The plants may be set in individual pots if the propagator prefers, the pots being bedded to the rim in the sand.

(7) Cover the frame with muslin or other white shade suspended above the glass, giving the plants plenty of light but little or no direct sunlight, and for the first two or three months keep the temperature at not to exceed 65° F. if practicable. When subjected to high temperatures the newly cut shoots are liable to die and rot from the base upward.

(8) Watering should be as infrequent as practicable, only sufficient to keep the soil moist but well aerated, not soggy.

(9) The frame should receive ventilation, but not enough to cause the new twigs to droop. These are most susceptible to overventilation and to overheating when they have nearly completed their growth. (Pl. VIII.)

(10) After the new twigs have stopped growing and their wood becomes hard new root growth takes place. Then secondary twig growth follows, either from the apex of the new twigs or from another bud lower down on the old wood of the original rooted shoot. Until this secondary twig growth takes place the life of the plant is not assured.

SOIL MIXTURES FOR BLUEBERRIES.

A very successful potting mixture or nursery-bed mixture for blueberry plants consists of one part, by measure, of clean or washed sand, nine parts of rotted upland peat, either chopped or rubbed through a sieve, and three parts of clean, broken crocks—that is, pieces of ordinary unglazed, porous, earthenware flower pots. No loam, and especially no lime, should be used. Manure is not necessary, and in the present state of our knowledge may be regarded as dangerous, although in small quantities it serves to stimulate the plants, at least temporarily. The danger from manure apparently lies in its tendency to injure the beneficial root fungus of the blueberry plant.

The use of broken crocks in the potting mixture is based on the fact that the rootlets seek them and form around them the same kind of mats that they form at the wall of the pot, thus increasing the effective root surface and the vigor of growth. If crocks are not available, the soil mixture should consist of two to four parts of peat to one part of sand.

The peat most successfully used for potting blueberry plants is an upland peat procured in kalmia, or laurel, thickets. In a sandy soil in which the leaves of these bushes and of the oak trees with which they usually grow have accumulated and rotted for many years, untouched by fire, a mass of rich leaf peat is formed, interlaced by the superficial rootlets of the oak and laurel into tough mats or turfs, commonly 2 to 4 inches in thickness. These turfs, ripped from the ground and rotted from two to six months in a moist but well-aerated stack, make an ideal blueberry peat. A good substitute is found in similar turfs formed in sandy oak woods having an underbrush of ericaceous plants other than laurel. The turfs of lowbush blueberries serve the same purpose admirably. Oak leaves raked, stacked, and rotted for about 18 months without lime or manure are also good. The leaves of some trees, such as maples, rot so rapidly that within a year they may have passed from the acid condition necessary for the formation of good peat to the alkaline stage of decomposition, which is fatal to blueberry plants. Even oak leaves rotted for several years become alkaline if they are protected from the addition of new leaves bearing fresh charges of acidity.[6] The much decomposed peat

[6] For a fuller discussion of the conditions under which leaves decompose into leaf peat as distinguished from leaf mold, and the fundamentally different effect of the two on the growth of plants, consult "The Formation of Leafmold," Smithsonian Report for 1913, pp. 333 to 343 (also separately printed).

in the submerged lower layers of deep bogs, such as is used for fuel in Europe, is not suitable for blueberry-soil mixtures.

TUBERING.

By ordinary methods cuttings of the swamp blueberry could at first be rooted only in occasional instances. Successful special methods, however, were afterwards devised for these plants. The most novel of the methods devised, but the one easiest of operation, is that of tubering. This method involves the same principle as that employed in stumping, namely, the forcing of new shoots in such a manner that their basal portions are morphologically scaly rootstocks, with a strong rooting tendency. The directions for tubering as applied to the swamp blueberry are as follows:

(1) Make stem cuttings from outdoor plants between midwinter and early spring, before the buds have begun to make their spring growth, and preferably on a warm day when the twigs are not frozen. A still better plan is to make the cuttings in autumn after the leaves have fallen and store them for about two months in moist sphagnum moss or clean basswood sawdust on ice at a temperature just above freezing.

(2) The cuttings are to be made from vigorous plants grown in well-lighted situations and with stems therefore well stored with starch. Use unbranched portions of the old and hardened branches and stems, about a quarter of an inch to an inch, or even more, in diameter. From 3 to 4 inches is a suitable and convenient length. Make the cuts with pruning shears or a fine-toothed saw and remove the bruised wood at the cut ends with a sharp knife. Be careful not to injure the bark or split or strain the wood.

(3) Lay the cuttings horizontally in a box about 8 inches deep in a bed of pure clean sand and cover them to the depth of about three-quarters of an inch with a mixture of sifted rotted peat (two parts) and clean sand (one part). Or the whole bed may be composed of sand mixed with about an equal bulk of peat. Or the bed may consist of a mixture of basswood sawdust and peat, described under "Winter cuttings." Moisten the bed well with rain water, bog water, or other pure water (free from lime) from a sprinkling pot and see that the bed is closely and firmly packed about the cuttings. Cover the box or cutting bed with a pane or panes of glass, the top of the box being flat, so that the glass fits it rather snugly. The box should be so prepared that any surplus water will drain away beneath through holes in the bottom covered with clean broken crocks and sphagnum moss.

(4) Keep the box at a temperature of 55° to 65° F. or as near those limits as practicable. A temperature of 70° or over is likely to ruin the cuttings.

(5) To avoid excessive temperatures, do not allow direct sunlight upon the glass, either keeping the box by north light or keeping it shaded, as by a white cloth or paper cover suspended several inches above the glass, or in a shaded greenhouse.

(6) Keep the air over the bed saturated with moisture. This condition will be evidenced by the condensation of the moisture on the under side of the glass during the cooler part of the day or whenever a cold wind blows against the glass.

(7) Watering should be as infrequent as practicable, only sufficient to keep the cutting bed moist but well aerated and the atmosphere above it saturated. If the glass fits tightly, a second watering may not be needed for several weeks.

(8) Within a few weeks new growth will begin to appear above the soil. (Pl. IX, fig. 1.) When the shoots have reached a length proportionate to their vigor, commonly 1 to 3 inches, their further growth is self-terminated by the death of the tip. After the leaves have reached their full size and acquired the dark-green color of maturity the time has come for the development of roots.

(9) The new growth, which if it had originated above the bed would be like an ordinary shoot, was transformed in working its way through the soil and became a scaly, erect rootstock, which on reaching the surface of the bed continued its development into a leafy shoot. During the spring and early summer roots form in abundance on the lower or rootstock portion of these shoots. (Pl. IX, fig. 2.)

(10) After a shoot is well rooted it commonly, though not invariably, makes secondary twig growth the same season, usually from a bud in the axil of the uppermost leaf. If the rooting of the shoot has not already been ascertained by direct examination, the making of such secondary growth is good evidence that rooting has actually taken place.

(11) When a shoot is well rooted, with roots 1 to 2 inches in length, it is ready to be potted. (Pl. X.) If the shoot has not already disconnected itself from the dead cutting it should be carefully severed with a sharp knife. In the process of tubering the behavior of the cuttings is essentially identical with that of real tubers, like those of the potato. The original cutting dies, but the sprouts that arose from it root at the base and form independent plants.

(12) The rooted shoots should be potted in clean 2-inch earthenware pots in the standard blueberry-soil mixture already described. (Pl. XI.)

(13) The pots should be bedded in moist sand up to the rim in a glass-covered frame or box, well lighted but protected from direct sunlight and slightly ventilated but with a saturated or nearly saturated atmosphere.

(14) To obtain rapid growth, gradually accustom the rooted plants to a well-ventilated atmosphere and then to half sunlight, this adjustment extending over a period of about three or four weeks.

(15) If preferred, the rooted shoots may remain in the original cutting bed until the following spring, the cutting bed being exposed during the winter to freezing temperatures, but mulched with oak leaves, and the plants may then be transferred, with their whole root mat intact, to a peat and sand nursery bed at a spacing of about a foot each way.

Where propagating is to be done on a sufficiently large scale, outdoor coldframes may be used instead of cutting boxes. At Whitesbog the process of tubering has been carried on with great success in muslin-shaded coldframes, and the handling of the cuttings, both before and after rooting, has been such simplified. The cuttings are made in the fall, packed in boxes in loose, moist, clean sphagnum moss or basswood sawdust, and stored during the winter in a cool cranberry house at a temperature of about 40° F. As soon as the frost is out of the ground beds of clean sand are laid down in the coldframes, and the cuttings are pressed into the sand until the upper side is level with the surface. The whole is then covered with an inch layer of sifted peat (about two parts) and sand (one part). At first the frames were completely shaded by clean

white muslin on a framework about 7 feet above the ground (Pl. XII, fig. 1). They are given a small amount of ventilation.

In 1919 and 1920 an experiment was tried at Whitesbog, on the recommendation of Mr. V. A. Vanicek, an expert plant propagator of Newport, R. I., in the use of lath instead of muslin shades. The shades are so constructed that the lath is about 4 inches above the sash of the coldframe, and the distance between the laths is the thickness of a lath, about a quarter of an inch. (Pl. XII, fig. 2.) This construction allows each cutting to receive direct sunlight, but for only a few minutes at a time. The proportion of cuttings that rooted under these lath shades was a little better than that under the muslin shades. It is to be hoped that further experience with lath shades will establish their apparent superiority over muslin shades, for they are less expensive and more easily handled.

The shades and sash are removed in early October, and in late autumn, after most of their leaves have fallen, the rooted plants are taken out of the frames, so that these can be made ready for a new lot of cuttings very early the next spring. The strongest of the rooted plants taken out of the frames are sometimes set at once in their permanent places in the field plantation. The others are placed in nursery beds at a spacing of about 10 inches each way, where they remain during the winter and the following growing season.

The cutting bed should be watered often enough to keep it from drying at the surface.

WINTER CUTTINGS.

The rooting of leafy cuttings of the blueberry in summer is difficult, because in a temperature above 70° F. the cuttings usually blacken and die. With the aid of a shaded greenhouse, winter cuttings can be started early enough to make roots before warm weather comes on. Similar results can be obtained in coldframes so located, sheltered, and manipulated as to prolong their low temperature as late as possible into the season.

The essentials of a successful coldframe for blueberry propagation are as follows: (1) It should be located on the cool, shaded north side of a building or in some other situation where it will not receive reflected heat from neighboring structures. (2) The cuttings should receive an abundance of light but little or no direct sunlight, a condition best obtained in the case of isolated frames by the use of muslin or slat shades. Frames on the north side of a building will also require shade in early morning and late afternoon from March to September. On sunless days all shade should be removed, so that the cuttings will receive as much light as possible. (3) There should be ample space for the circulation of cool air between the frames and the shade. (4) The frames should be kept closed or nearly closed,

with a little ventilation at night to refill the frame with cool air, until the cuttings are rooted. The closing not only keeps the air saturated with moisture and prevents the drying of the cuttings, but it also tends to maintain a cool ground temperature within the frame.

The use of a greenhouse in which to start the cuttings, followed by the transfer of the cutting boxes to coldframes at the beginning of warm weather, permits an even more prolonged protection of the cuttings than can be obtained in either greenhouse or coldframes alone and increases the percentage of rooted plants. The directions for rooting winter cuttings of the blueberry by this method are as follows:

(1) Make the cuttings in late autumn, removing any leaves that have not already fallen.

(2) Make the cuttings from wood of the preceding summer's growth, rejecting such portions as bear the large fat flowering buds. The cuttings are to be made from well-matured unbranched twigs or shoots grown in well-lighted situations and therefore well stored with starch.

(3) About 4 inches is a suitable length for finished cuttings. A sharp thin-bladed knife should be used. In the finished cutting, the upper end of the diagonal cut at the base of the cutting should come just below a sound bud, and the cut at the upper end of the cutting should be about an eighth of an inch above a sound bud. If the cuts are first made with pruning shears, remove with the knife the bruised wood at the cut ends. The diagonal knife cuts should be as short as is practicable without bruising the bark or splitting or straining the wood. To avoid infection of the cuttings, the knife must be kept clean. This may be done conveniently by dipping the blade in alcohol and wiping it on a clean towel. The cuttings must not be allowed to become dry. This is easily prevented by laying them in the fold of a clean moist towel.

(4) The cutting box (Pl. XIV) should be made of sound clean wood, about 8 inches deep inside and of any convenient size, with drainage holes in the bottom. The cutting bed should be laid down over a groundwork of clean broken crocks, gravel, or other material that will provide good drainage. On this place about 3½ inches of rather coarse basswood sawdust mixed with about one-fourth its bulk of peat, the whole bed, including the drainage material, being 4 inches or a little more in thickness. Wet the bed thoroughly with clean rain water or other pure water (free from lime) from a sprinkling pot.

(5) With a newly whittled stick or other clean implement punch holes about 3 inches deep in the cutting bed at a spacing of 2 to 3 inches each way, according to the thickness of the cuttings. In setting the cutting in the hole be sure to press it down far enough and firmly enough to make sure that the cut surface at the base is in contact with the sawdust, but be careful not to injure the delicate new tissue at the base of the cutting by pushing it forcibly into the cutting bed. With the stick tamp the sawdust firmly about the cutting. Cover the box with a pane or panes of glass.

(6) To prevent injury of the cuttings by overheating, allow little or no direct sunlight on the boxes. Shade them with muslin or paper or slats so hung as to permit ample circulation of cool air between the shade and the glass.

(7) Keep the air inside the box saturated or nearly saturated with moisture. This condition will be shown by the condensation of the moisture on the under side of the glass at night or at other cool portions of the day.

(8) Watering should be as infrequent as practicable, only sufficient to keep the cutting bed moist but well aerated and the atmosphere in the box saturated. If the glass fits tightly, the period between necessary waterings may extend over several weeks.

(9) Place the box for a month in a temperature of 55° to 60° or 65° F., in either darkness or indirect sunlight. At the end of a month the new healing-over growth, called a callus, should have formed at the base of each cutting.

(10) After the cuttings are callused the temperature in the cutting house should be allowed to run down each night to a temperature of 35° F. or as near that point as the weather permits, but the cuttings should not be allowed to freeze. The day temperature should approach but not exceed 60°. Shade the boxes from direct sunlight, but give them all the indirect light practicable.

(11) After two months of this alternate chilling and moderate warming the buds on many of the cuttings should have begun to push. It is then time to raise the night temperature to 55°, keeping the day temperature at about 60° F.

(12) After new twigs have developed from the upper buds (Pl. XIII) and their growth has been terminated by the browning and shedding of the tips, and the new leaves have reached their full size and acquired the dark-green color of maturity, the formation of roots is about to begin. (Pl. XIV, fig. 1, and Pl. XVI.)

(13) When all or most of the cuttings in the frame have begun to root, ventilation of the box should be begun. The best superficial evidence that a cutting has rooted is the development of secondary twig growth, either from the apex of one of the first set of new twigs or from another bud lower down on the old wood of the cutting. (Pl. XIV, fig. 2, and Pl. XV.) If secondary growth does not take place, the development of a plump but dormant bud at the apex of one of the leafy twigs is also good evidence that the cutting has begun to root. Cuttings that are healthy but not yet rooted at the time ventilation begins usually die from excessive transpiration.

(14) Ventilation should be only slight at first and should be increased very gradually, the transition to full ventilation extending over a period of several weeks. If any of the sensitive secondary growth begins to wilt, reduce the ventilation immediately until the wilting ceases. Be especially careful not to give too much ventilation on windy days. By the time the tips of the secondary shoots are browned and shed and their leaves are mature in size and color, the cuttings have developed sufficient root growth to warrant full ventilation.

(15) All cuttings that are dying should be removed from the bed at once. Those injured by high temperature usually turn brown at the base first, the dead area extending upward until the new growth collapses. Those otherwise sound but suffering from excessive ventilation before they are rooted usually indicate their bad condition by the marginal yellowing of their leaves before they drop and the stems become withered.

(16) The plants are best left in the cutting bed all winter, either indoors at a temperature slightly above freezing, or outdoors mulched with leaves, preferably oak leaves. In early spring, before the buds have begun to push, they should be very carefully lifted and moved, with the whole root mat and adhering soil intact (Pl. XVI), to a peat and sand nursery bed at a spacing of about a foot each way or potted in the standard blueberry-soil mixture.

ROOT CUTTINGS.

The early experiments with root cuttings gave such a small percentage of rooted plants that further experiments in the greenhouse were abandoned. At Whitesbog, N. J., however, in order that the

underground parts as well as the tops of selected wild plants might be utilized, cuttings of these parts were made, about 3 to 4 inches long and of all sizes down to a little less than an eighth of an inch in diameter. These were given the same treatment as tubered cuttings in coldframes. A good percentage of unusually vigorous rooted sprouts resulted. (Pl. XVIII.) It was found later, however, that most of the pieces that rooted were not true root cuttings, but were from underground portions of stems, properly stem-base cuttings.

MOUND LAYERING.

Wild blueberry plants, and hybrids also, vary greatly in their response to the different methods of propagation here described. Cuttings of the common lowbush blueberry (*Vaccinium angustifolium*) usually do not yield a large percentage of rooted plants. The same is true of hybrids between this species and the swamp blueberry. For these plants the old-fashioned method of mound layering has been found satisfactory. The procedure is simply to cover up the bases of the stems to the depth of 2 to 4 inches with the peat and sand soil in which the plants are growing. If this is done in spring, soon after flowering, the stems are usually well rooted by the end of the season, and each one is ready to be taken off as a separate plant.

TREATMENT OF YOUNG PLANTS.

When blueberry plants, either large or small, are grown in porous pots, the surface of the pot should never be allowed to become dry, for the rootlets which grow through the soil to the wall of the pot for air are extremely fine and easily killed by drying, to the great injury of the plant. This danger may be eliminated by bedding the pots to the rim in a well-drained bed of sand or by setting the pot in another pot of 2 to 4 inches greater diameter, with a packing of moist sphagnum moss between and broken crocks at the bottom.

A burning of the young leaves and growing tips of twigs is often produced by the hot sun from the middle of June to the middle of September. Plants in pots or nursery beds are easily protected from such injury and forced to their maximum growth by a half-shade covering of slats, the slats and the spaces between being of the same width. On cloudy days the shade should be removed. It should not be used in the fall or spring.

During the winter blueberry plants should be kept outdoors, exposed to freezing temperatures, their soil mulched with leaves, preferably oak leaves. When kept in a warm greenhouse during the winter they make no growth before spring. Even then their growth is late, abnormal, often feeble, sometimes deferred for even a whole year.

FIELD PLANTING.

Plants from cuttings or rooted shoots are ready for permanent field planting when they are 1 or 2 years old and 6 to 18 inches high. (Pls. XIX and XX.)

It is a curious fact that these plants send out no new roots in spring until they are in full leaf, when their flowering is nearly or quite finished and their principal twig growth has ceased. It is important, therefore, in taking up either a wild or a cultivated plant from the open ground that as much as possible of the old root mat be carefully lifted with the plant, for upon these old roots the plants depend for moisture until their new rootlets are formed, about two months after the first signs of growth in spring.

In the case of mature wild bushes with very large root systems, when it is practicable to secure but a fraction of the root mat, say a disk only 3 or 4 feet in diameter, it is the best procedure to cut all the stems at the time of transplanting to stumps 1 to 2 inches high. The bush will then produce a new and symmetrical top of a size suited to the capacity of the roots. The wood that is removed may be used for cuttings if the plant is sufficiently valuable.

The stems that make up a bush usually develop fibrous roots on their basal portions beneath the surface of the soil and above the root crown, at which the several stems unite. Such plants can be divided into several when taken up for transplanting. As many as 30 plants, each cut to a stump and with its own small but sufficient portion of the root mat, have been obtained in this way from a large wild plant. By utilizing the various methods of propagation described in this bulletin, as many as 600 cuttings of roots, stems, and twigs have been made from a single very large wild bush.

In resetting plants from which the tops have been removed, the stumps should be made to project about an inch above the surface of the ground. New shoots are formed in spring from such exposed stumps much earlier than from stumps covered with soil and not receiving the warmth of the sun's direct rays. If the plant when reset is made to occupy a moderate depression in the ground, the old stump and the bases of the new stems can afterward be covered with soil, and a new root system will finally develop from the new wood.

When blueberry plants are set out in early spring, before the buds have begun to push, they usually make excellent growth, and for all plants that are pruned to the stump early spring is the best season for transplanting.

Conditions with unpruned plants, however, are different. Since blueberry plants make no new root growth until late spring, it often happens that a period of hot days intervenes between planting and

rooting, and many plants are injured by an excessive loss of water before they have had time to make connection with the water supply of the surrounding soil through the development of new roots. The danger of such injury is greatest in the case of plants transplanted from pots. The old root ball sends up most of its water to the leaves, and in consequence, being at first as a rule in imperfect capillary contact with the new outside soil, the root ball commonly contracts slightly. The contraction is often sufficient to put the roots at the sides and bottom of the root ball permanently out of contact with the surrounding soil, and the plant may continue to suffer severely from drought, although the soil outside the root ball contains plenty of moisture.

An early autumn field planting has furnished a remarkably successful means of avoiding this trouble with potted plants. At this season the excessive heat of summer is over, the plants are in full and vigorous leaf, and, being taken from pots, carry their whole root system with them. The formation of new roots begins at once and proceeds with great activity until the leaves are shed, at the approach of winter. In the spring, when new leaf growth begins, the plants are already well rooted in the soil. They pass through the early hot period without injury and develop remarkable size and vigor by autumn.

In preparing for a field plantation one precaution of special importance must not be overlooked. For the production of a crop of fruit under field conditions, insects are required to carry pollen from one flower to another. The honeybee works little on blueberry flowers. Her tongue is so short that she can not easily reach the nectar. The flowers are pollinated chiefly by bumblebees, whose tongues are long, and by some of the solitary wild bees that are small enough to crawl through the narrow opening of the corolla. (Pl. XXI.) When blueberry flowers are pollinated with pollen from their own bush the berries are fewer, smaller, and later in maturing than when the pollen comes from another bush. Some bushes are almost completely sterile to their own pollen. (Pl. XXII.) The pollen of a plant grown from a cutting is likewise unsatisfactory for the pollination of the parent plant or of other plants grown from its cuttings. It is important, therefore, that a plantation should not be made up wholly from cuttings from one bush. Two stocks should be used, a row of plants from one stock being followed by a row from the other.

In the permanent field plantation bushes of the wild swamp blueberry or its hybrids should be spaced 8 feet apart each way. When they reach mature size they will nearly or quite cover the intervening spaces. When first planted, however, the bushes are preferably set

4 feet apart in the row, with the rows 8 feet apart. (Pl. XXIII.) This spacing permits machine cultivation in one direction. When the bushes begin to crowd each other, every second plant in the row will need to be removed. If the plants are set originally at 4 by 4 feet machine cultivation will be impracticable after the first year or two, and the branches of the bushes are likely to begin to interlock after five or six years.

For lowbush hybrids it seems probable, from the experience at Whitesbog, that a spacing of 6 by 3 feet will give the bushes adequate room for many years. If the bushes ultimately begin to interlace in the rows the removal of every second bush would then leave them at intervals of 6 by 6 feet.

This removal of filler bushes will furnish a large quantity of propagation material, which can be rooted by the various methods described in this bulletin and used for the extension of the plantation.

When blueberry culture is to be tried in a sandy or gravelly soil deficient in peat or peatlike matter, the plants should be set in separate holes or trenches about 12 inches deep in a mixture of two to four parts of peat or half-rotted oak leaves to one part of clean sand. The excavations should be wide enough to provide ample space for new growth of the roots, not less than a foot each way from the old root ball. In small plantings, if the materials for the mixture are easily available in quantity, an 8-inch bed of it may be laid down over the whole surface of the ground, and if a planting is to be tried on a soil wholly unsuited to the blueberry, especially a rich garden soil or a heavy soil affording poor drainage, the area may first be covered with a 2-inch layer of soft-coal cinders, to keep earthworms from bringing up the underlying soil, next a 6-inch layer of sand, for drainage, and finally the 8-inch bed of peat and sand mixture. Wherever used, the peat and sand mixture should be thoroughly manipulated, so as to give it a uniform texture, before the plants are set out in it, for in a soil in which layers of peat alternate with layers of sand the capillary connection of the two is usually imperfect, and a plant rooted in the peat may suffer severely from drought, although the neighboring sand still has water to spare. For a similar reason it is important that when the plant is first set out the peat and sand mixture shall be very tightly pressed and packed about all sides of the old root ball.

To insure full vigor of growth the ground between the bushes must be kept free from all other vegetation. On rocky uplands or in situations deficient in peat a continuous mulch of oak leaves, when it is practicable to procure them, will help toward this end, as well as keep the soil in the necessary acid condition. It is more economical, however, to choose such a location for the plantation

as will permit the use of horse-drawn machinery and will make mulching unnecessary.

The most favorable location for blueberry culture is a moist area with a peat covering and sand subsoil, the peat preferably of such a thickness that deep plowing will turn up some of the underlying sand.

The land should be so ditched or tiled that the water level can be kept at least a foot below the surface of the ground during the growing season.

The ground should be plowed to the depth of 8 to 10 inches and repeatedly harrowed or otherwise tilled during the season preceding the planting, in order to kill the wild vegetation. The best time for such plowing is in late spring, after the principal vegetation has used up its winter store of starch in completing its early growth and before the leaves have matured and the roots have begun the new storage of starch by means of which they could send up new sprouts.

The tillage of the plantation after the young bushes have been set out should be sufficiently thorough to keep down all competing vegetation. This is best done by horse cultivation with a disk harrow, supplemented by careful hand hoeing and hand weeding close about the plants. As the bushes grow older and their roots extend into the spaces between the rows, they develop root mats close beneath the surface of the soil. The tillage over these root mats should be very shallow, not more than 2 or 3 inches. This is probably best accomplished by the use of a small, light spring-tooth cultivator with the teeth set closer together than usual. (Pl. XXIV.)

In case of drought, the drainage ditches may be used to bring in water for subirrigation. But unless the surface of the ground is very level, subirrigation is likely to result in the injury of plants in the lower spots by excess of water. In uneven areas, therefore, surface or overhead irrigation, if accompanied by good drainage, is preferable to subirrigation and should be used if practicable.

Fertilizer experiments have shown that the application of lime or of wood ashes is positively injurious to blueberry plants and that stable manure, while producing a temporary stimulation of vegetative growth, is likely to cause serious injury later.

In greenhouse experiments at Washington it has been found that blueberry plants are greatly stimulated by the application of small quantities of soy-bean meal, either mixed with the soil or applied as a mulch. This material is acid, it has a high nitrogen content, and its nitrogen is in organic form. Blueberry plants to which it is applied in spring, as compared with plants not fertilized, make more

stocky growth and lay down many more fruit buds for the succeeding year.

On an area at Whitesbog in which the proportion of peat to sand was too small to bring about the most vigorous growth of the bushes, an experiment was made in the application, at the rate of 600 pounds per acre, or one-eighth of a pound per square yard, of a special fertilizer which is in successful use in cranberry culture as the result of a series of experiments by the New Jersey State Agricultural Experiment Station. Important characteristics of this fertilizer are its acidity and its comparative freedom from residues of sulphur. The blueberry bushes to which this fertilizer was applied made conspicuously better growth than those that were not fertilized, but they neither grew better nor fruited better than bushes mulched with 1 to 2 inches of rotted peat.

In 1919 and 1920 Mr. Charles S. Beckwith, of the New Jersey Agricultural Experiment Station, conducted a series of fertilizer experiments with blueberries at Whitesbog. The most successful results were obtained with a fertilizer applied in the spring of 1919, made up as follows:

	Pounds.
Nitrate of soda	170
Dried blood	230
Steamed bone	340
Phosphate rock	340
Potash	170

The yield in 1920 from bushes thus fertilized was more than three times as great as from unfertilized bushes in the same very sandy soil. On the basis of this experiment Mr. Beckwith has recommended the application of this fertilizer at the rate of 600 pounds per acre, or an eighth of a pound per square yard.[7]

As a result of these preliminary fertilizer experiments and in view of the fact that the swamp blueberry fruits abundantly and continuously in soils containing the proper proportion and quality of peat and sand, the use of manure or any chemical fertilizer in such plantations is not at present advocated. But if the proportion of peat to sand is so low that the bushes appear to be suffering for nourishment a mulch of rotted surface peat or half-rotted oak leaves should be applied, or a chemical fertilizer similar in character to the one described above, or some organic nitrogenous substance, such as soy-bean meal or cottonseed meal.

The swamp blueberry does not require a yearly pruning. When one of the stems of a bush becomes unproductive from injury or old age it should, of course, be cut out. If a large part of a bush needs removal it is better to cut all the stems to the ground and let the

[7] For the details of this experiment, see "The Effect of Fertilizers on Blueberries," published in Soil Science, v. 10, pp. 309 to 312, with plate, October, 1920.

plant send up new shoots, all of the same age, to form a wholly new and symmetrical top. With lowbush hybrids it has been found desirable at Whitesbog to remove each year, in late July or early August, immediately after the picking season, all the stems more than 1 year old which have not made vigorous new twig growth during the season. Under such treatment the bushes yield a good crop of berries every year. Farther north, where the growing season is shorter, such pruning should be done in late autumn or very early spring.

It has long been known that the occasional burning of lowbush blueberry areas increases the yield of fruit. In the blueberry canning districts of Maine this has led to the development of a system of burning the blueberry barrens once in three years. In the summer following the burning the plants do not fruit, but they send up from the ground an enormous number of vigorous unbranched big-leaved stems. Late in the season fruit buds are formed in abundance on the upper part of these stems, and in the second summer after the burning the plants fruit heavily. They are likely also to yield fairly well the third summer, but after that they usually become unproductive. The burning should be done in the dormant season when the plants have dropped their leaves and the roots are fully stored with starch and other reserve foods. From these stored materials are formed the vigorous sprouts of the following spring. If an area is burned in late spring or in summer, after the stored food materials have been used up and before the storage for the following year has taken place, the plants will be seriously weakened. The best time for burning is in early spring, before the buds have begun to push. A day should be selected when the upper layers of dead leaves are dry enough to carry a fire and the underlying turf of upland peat is still wet. For if the fire burns so deeply as to consume the layer of peat, from which the plants derive the principal part of their nourishment, their later growth and their fruiting vigor will be seriously impaired. The beneficial effect of burning a blueberry area has led to the idea that wood ashes are a good fertilizer for blueberries. Experiments have shown, however, that one of the most effective ways to kill a blueberry plant is to give the soil an application of wood ashes sufficient to neutralize its acidity. When a blueberry area is properly burned the layer of ashes is very thin, quite insufficient to neutralize the acidity of the underlying peat turf, and therefore harmless, probably indeed under these conditions beneficial. The chief benefits from burning are two, both quite distinct, however, from the fertilizing effect. Burning tends to keep down tree growth and other competing vegetation, and it prunes the blueberry bushes. Burning is by far the least expensive and most effective method known for pruning lowbush blueberries. The procedure is espe-

cially adapted to the management of wild uncultivated areas of the two common lowbush species of the northern United States, *Vaccinium angustifolium* and *V. canadense*. Since the highbush blueberry, *Vaccinium corymbosum*, however, requires drastic pruning only at intervals of many years, and even then at different times for different bushes, burning is not a good method for pruning this species. This is especially true of cultivated plantations, where competing vegetation is kept down by other means.

YIELD.

By proper manipulation in the greenhouse, seedling blueberry plants can often be made to ripen a few berries when they are 1 year old, but they do not come into commercial bearing in field plantations until they are about 4 years old (Pls. XXV to XXIX), when the plants are 1 to 3 feet high. They then increase slowly to full size and full bearing. Wild bushes of the swamp blueberry live to great age, often 50 to 100 years, still bearing heavily, and they often attain a height of 6 to 8 feet when growing in full sunlight; still more when shaded. Individual stems may remain productive from 10 to 25 years. When dead they are replaced by new and vigorous shoots from the root.

The great promise of blueberry growing as an agricultural industry, in just the right soil and under good business management, is indicated by the yields from the oldest of the hybrid plantings at Whitesbog. This planting consists of about a third of an acre, the plants 7 years old in 1919. They yielded in that year at the rate of 96 bushels per acre. The berries sold at a little over $10 a bushel, in addition to express charges and commissions, the receipts being at the rate of $966 per acre. In 1920 this planting yielded at the rate of 117 bushels per acre, with receipts at the rate of $1,280 per acre. These plants were set at 3 by 5 feet and consequently yielded about twice as much per acre at this age as they would if they had been spaced as now advocated, at 4 by 8 feet.

The yields from this planting, from the beginning, are shown in Table I.

TABLE I.—*Yield and receipts from a planting of hybrid blueberries at Whitesbog, N. J., 1915 to 1920, inclusive.*

Year.	Computed yield per acre.	Approximate price per quart.	Value of crop per acre.	Year.	Computed yield per acre.	Approximate price per quart.	Value of crop per acre.
	Bushels.	*Cents.*			*Bushels.*	*Cents.*	
1915	6.6	18	$37	1918	[a] 46.9	30	$449
1916	29.7	22	209	1919	95.8	32	966
1917	58.3	24	448	1920	117.3	34	1,280

[a] Yield reduced by late spring frosts.

With beginners in blueberry culture every gradation in accomplishment may be expected, from the great success indicated above to complete failure because of wrong soil, bad location, or poor management.

The heaviest charge against the industry is the cost of producing rooted plants of selected varieties. At the present time plants of the best varieties can not be purchased in acre quantities. The grower must do his own propagating from a few plants. The propagation is sufficiently difficult to demand unusual skill, and it requires constant and painstaking attention.

If the land to be used bears timber and brush the clearing is expensive.

After a plantation is established its maintenance is relatively inexpensive. The cost of cultivation is rather less than that of the staple cultivated crops. The principal charge is for the picking of the berries. At Whitesbog 6 cents a quart has been paid for the last few years. A good picker in an ordinary day picks about a bushel. An exceptionally skillful picker, with unusually favorable bushes, has picked 100 quarts, or more than 3 bushels, in a day. For shipment to the market in crates cultivated blueberries should be picked by hand, never with a "rake" or "scoop," such as is used when blueberries are carted direct to commercial canneries.

HYBRID BLUEBERRIES.

Blueberry breeding has now been carried on for 10 years, with the result that instead of berries the size of peas, like the ordinary wild blueberry, we now have hybrids producing berries the size of Concord grapes. (Pls. XXVII to XXIX.) A few plants out of the 18,000 hybrids that have been fruited at Whitesbog are of the size shown in these illustrations, with berries three-fourths of an inch in diameter. A very few have borne berries even larger, a little more than four-fifths of an inch in diameter, and in the greenhouse a diameter of seven-eighths of an inch has been reached. In the great majority of the hybrids, however, the berries are intermediate in size between ordinary wild ones and the selected hybrids. (Pl. XXVI.) All such small and intermediate hybrids are rejected. Propagation material placed in the hands of nurserymen for commercial propagation is taken from the selected hybrids only.

The unselected hybrid berries vary in color from light blue to dark blue and sometimes shining black, and an occasional bush bears red berries, or even white ones.

The variation of the blueberry hybrids in other respects is also very marked, the plants offering an almost endless opportunity for selection with reference to acidity, sweetness, flavor, juiciness, firm-

ness, productivity, hardiness, season of ripening, resistance to fungous diseases, and many other less important characteristics. In making the selections, special consideration has been given to the form of the bush and its possession of a foliage surface adequate to the nourishment of a large crop of berries. (Pl. XXV.)

CONCLUSION.

The introduction of the blueberry into agriculture has a much more profound significance than the mere addition of one more agricultural industry to those already in existence. Blueberries thrive best in soils so acid as to be considered worthless for ordinary agricultural purposes. Blueberry cultivation, therefore, not only promises to add to the general welfare through the utilization of land almost valueless otherwise, but it offers a profitable industry to individual landowners in certain districts in which general agricultural conditions are especially hard and unpromising, and it suggests the possibility of the further utilization of such lands by means of other crops adapted to acid conditions.[8]

[8] For a discussion of the principles of acid-soil agriculture in districts in which the cost of lime is prohibitory, consult "The Agricultural Utilization of Acid Lands by Means of Acid-Tolerant Crops," United States Department of Agriculture Bulletin No. 6, 1913.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
30 CENTS PER COPY

BLUEBERRY PLANTS SHOWING THE EFFECT OF ACID SOIL AS CONTRASTED WITH RICH GARDEN SOIL.

The three large 1-year-old blueberry plants were grown in a greenhouse in a peat soil. All three are over 24 inches high, the one at the left 27 inches. Standing on the middle pot is a small glass pot containing a seedling of the same age and origin as the others but potted in a rich garden soil. The difference in results shows the fundamental importance of a peaty acid soil for blueberry culture. (One-eighth natural size.)

NEWLY INSERTED BUD ON A BLUEBERRY PLANT.

After loosening the bark of this ordinary plant along a T-shaped cut, a bud sliced from a selected hybrid has been placed in the cut and bound tightly in place with raffia fiber. For detailed directions for budding, see page 6. (Natural size.)

BLUEBERRY PLANT FRESHLY BUDDED IN THE FIELD.

This plant, cut to the ground in early spring, sent up several strong, vigorous shoots. Photographed on July 18 after the insertion, on each shoot, of a bud from a choice variety. The bud wrappings are protected from the rain by a cone of waxed paper tied about the stem. The inserted bud becomes united with the stem in a few weeks and then lies dormant until the following spring.

NEW GROWTH FROM AN INSERTED BLUEBERRY BUD.

Photographed in the greenhouse on March 25. The plant had been budded in the preceding summer. Its top was cut off above the bud when the plant was brought into the greenhouse, late in February. Only the inserted bud is allowed to grow, all others being removed as soon as they begin to swell. The vigor of the whole plant is forced into the growth of the one shoot. (Natural size.)

BUD SHOOT MADE TO BRANCH BY REMOVING ITS TIP.

The principal object of budding is to grow as many cuttings as possible from the inserted bud. A plant with branches yields more cuttings than it would if unbranched, even though the single shoot grew to a greater height. (Natural size.)

FIRST YEAR'S GROWTH FROM FIVE INSERTED BUDS.

The illustration shows how much cutting wood may be produced in a single year from a budded plant. By using all this new growth for rebudding, the selected variety could be propagated on a still larger scale. Photographed August 3, when the plant was 32 inches high. After that date it made much further growth and a correspondingly larger amount of wood for cuttings.

NEW SHOOTS ON A STUMPED BLUEBERRY PLANT.

The three shoots shown grew after the plant had been cut to the stump. Their white color at the base indicates the depth of the propagating bed through which they forced their way and from which the plant was taken to be photographed. Roots had already begun to develop. (Natural size.)

BLUEBERRY PLANT FROM A ROOTED STUMP SHOOT.

The old cut-off stem shown in the illustration is the rooted base of a vigorous shoot from a stumped blueberry. It was removed from the parent plant a year after stumping, was potted in a 4-inch pot, and when photographed was in process of developing two new leafy branches. (Natural size.)

FIG. 1.—TUBERED BLUEBERRY CUTTING WITH YOUNG SPROUTS DEVELOPING.

FIG. 2.—TUBERED BLUEBERRY CUTTING WITH SPROUTS ROOTING AT THE BASE.

The sprout at the left in figure 1 had emerged from the sand and begun to develop green leaves above the surface. The sprout near the center of figure 1 is younger, the whole of it still in the rootstock stage. The two sprouts in figure 2 are developing roots on their lower parts, above the dying wood of the old cutting and beneath the surface of the cutting bed. (Both natural size.)

WELL-ROOTED SPROUTS FROM A TUBERED BLUEBERRY CUTTING.

Sprouts with roots thus far developed are ready for potting, even though secondary growth, as in this case, has not yet taken place. These two sprouts are so closely united that they can not be safely separated into two plants. (Natural size.)

NEWLY POTTED BLUEBERRY PLANT FROM A TUBERED CUTTING.

After the sprout from the tubered cutting had rooted and before it was potted it had made secondary growth from the tip of the original sprout. (Natural size.)

FIG. 1.—BLUEBERRY PROPAGATION FRAMES SHADED WITH MUSLIN.

Each sash is of the standard size, 3 feet wide and 6 feet long. The wooden sides of the cold-frames rise 2 feet from the ground at the back and 1 foot at the front. The lowest part of the roof joists is 6½ feet above the ground.

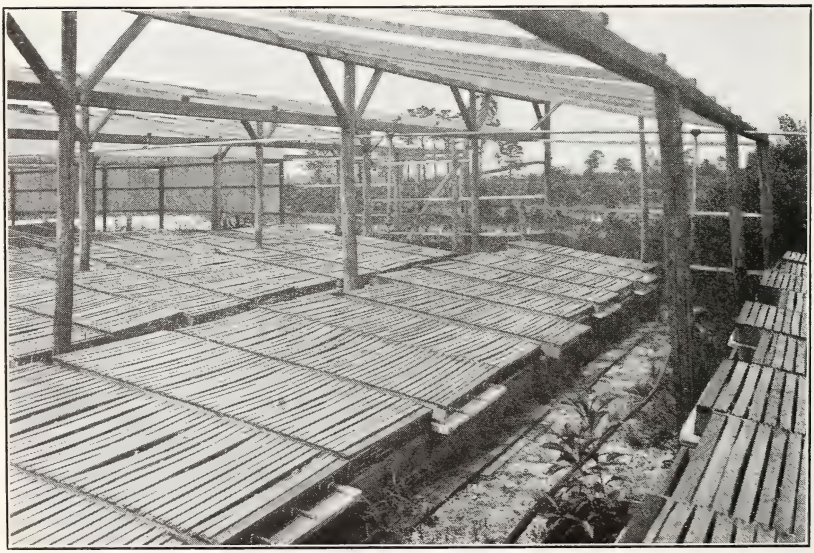


FIG. 2.—BLUEBERRY PROPAGATION FRAMES WITH SLAT SHADES.

Each sash has a separate, removable cover of builders' lath. The laths are separated from each other by a distance equal to the thickness of a lath. The posts shown in the illustration and the framework supported by them were originally made to carry muslin shades. They are not needed when slat shades are used.

BLUEBERRY CUTTINGS IN EARLY STAGES OF GROWTH.

The figure at the left shows a cutting callused at the base and the uppermost bud pushing, but the green bracts and young leaves not yet expanded. In the middle and right-hand figures callusing has proceeded farther at the cut surfaces, both top and bottom, and the formation of new leafy twigs is well under way; but the growth of the tips has not yet been terminated. As shown in the right-hand figure, twigs are often produced from two of the upper buds, sometimes more. (Natural size.)

FIG. 1.—WINTER CUTTINGS SHOWING PRIMARY GROWTH.

The box is 10 by 12 inches by 8 inches deep, inside measurement. The new twigs have completed their primary growth, their leaves have reached full size, and the formation of roots is about to begin. Secondary twig growth has not yet taken place.

FIG. 2.—BOX OF WINTER CUTTINGS SHOWING SECONDARY GROWTH.

Most of the cuttings have put out and matured their strong secondary twigs. This condition of twig growth is conclusive evidence that the cuttings are well rooted and that the box is ready for full ventilation.

BLUEBERRY CUTTING SHOWING SECONDARY TWIG GROWTH.

The cutting when first made was an unbranched twig. It was callused for a month, then chilled for two months, and then brought again into a temperature of about 60° F. From its stored food the cutting soon put out the short twig shown at the top of the illustration. When the four leaves on this twig had reached mature size and color and were manufacturing new food in the form of starch, roots began to form on the cutting. The roots brought in new mineral food, and then secondary twig growth took place in the form of the younger and stronger of the two twigs. (Natural size.)

WELL-ROOTED BLUEBERRY CUTTING.

This is one of a lot of 12 winter cuttings made on February 12 and set in a cutting box in a mixture of basswood sawdust (four parts) and upland peat (one part). On October 20 all 12 cuttings were well rooted, as shown in the illustration, from a photograph taken on that date, after the leaves were shed and winter dormancy had set in. (Natural size.)

WINTER TWIG CUTTINGS ROOTING IN A COLDFRAME.

The illustration, from a photograph taken on July 21, shows the cuttings at the time the roots are forming. Under this procedure the cuttings are made in the fall, from naked twigs that have just dropped their leaves. They are kept for a month at a temperature of about 60° F., during which time the cut surfaces heal by the formation of a callus. They are then kept at a temperature of 40° F. or a little less. In very early spring they are set in the coldframe, and as the result of their previous chilling their buds begin to swell with the first warm weather and they put out new leafy twigs. Until this new leafy twig growth has been completed, the cuttings can not form roots.

BLUEBERRY PLANTS FROM STEM-BASE CUTTINGS.

The illustration, from a photograph taken on July 27, shows the excellent growth secured from stem-base cuttings buried in a coldframe cutting bed early in the spring of the same year. This section of the coldframe is of the size of a standard sash, 3 feet in width and 6 feet from front to back.

TWO-YEAR-OLD BLUEBERRY PLANTS FROM CUTTINGS.

The plants are in 4-inch pots bedded in sand. Photographed on October 9, when the plants had completed the season's growth and were about to shed their leaves and become dormant. The compartments of the frame are 3 by 6 feet and the plants are 1 to 2 feet in height. Most of them are from selected hybrids.

TWO-YEAR-OLD BLUEBERRY PLANT FROM A CUTTING.

The plant here shown is 18 inches high and is in a 3-inch pot plunged in a 5-inch pot. Its roots are matted at the wall of the pot, so that the root-ball is very firm and admirably adapted to shipment by mail. When photographed, in January, the plant was in its dormant condition, with fat fruit buds ready to produce flowers and berries in the plant's third year. The first season after transplanting, however, it is better not to allow the production of flowers and fruit but to concentrate the energy of the plant on the establishment of a good root hold.

BLUEBERRY FLOWERS.

Photograph, taken at Whitesbog, N. J., on May 12, of a vigorous blueberry twig just coming into flower. In the preceding autumn and winter this twig was unbranched and naked. Its upper seven buds were fat flowering buds, often called fruit buds. Those below were leaf buds. From each of the leaf buds has grown a leafy shoot, from each of the flowering buds a cluster of flowers. For the relation of the flower structure to pollination by bees, see page 17. (Natural size.)

EFFECT OF SELF-POLLINATION IN THE BLUEBERRY AS COMPARED WITH CROSS-POLLINATION.

These two twigs, both natural size, were in equally good situations on the same bush, contained the same number of flowers, all pollinated by hand at the same time with equal care, and the fruits were photographed on the same day. The only difference in treatment was that the pollen used on the left-hand twig came from other flowers on the same bush, while the pollen for the right-hand twig was taken from another bush. The cross-pollinated flowers produced a full cluster of handsome fruit. The self-pollinated flowers produced no ripe fruit, all the fruit that set remaining small and green and later dropping off, until at the time the photograph was taken only two such imperfect fruits remained. A plantation made up wholly from cuttings from a single bush would produce little or no fruit. At least two original propagation stocks are necessary.

FIG. 1.—PLANTATION OF 2-YEAR-OLD AND 3-YEAR-OLD HYBRID BLUEBERRIES AT WHITESBOG, N. J.

The soil is a white sand mixed with upland peat and is strongly and permanently acid. The rows are 8 feet apart, the plants 4 feet apart in the row. The row at the left consists of 3-year-old plants; the others are 2 years old. Each of these plants is a seedling hybrid, and although of carefully selected parentage its own qualities can not be known until it fruits. The photograph was taken August 2, 1917.

FIG. 2.—PLANTATION OF 5-YEAR-OLD AND 6-YEAR-OLD HYBRID BLUEBERRIES AT WHITESBOG, N. J.

From the same point as figure 1, above, but from a photograph taken three years later, on July 26, 1920. The plants in the left-hand row are now 6 years old, the others 5. In the background a blueberry packing shed has been erected. At the right in the background are shown the gauze screens that are placed over selected bushes which are to be kept under special observation.

FIG. 1.—BLUEBERRY CULTIVATION WITH A DISK HARROW.

Character of the work done with a disk harrow. This tool is especially adapted for use when grasses or other turf-forming weeds have invaded the plantation and the ground must be loosened deeply and thoroughly.

FIG. 2.—BLUEBERRY CULTIVATION WITH A SPRING-TOOTH HARROW.

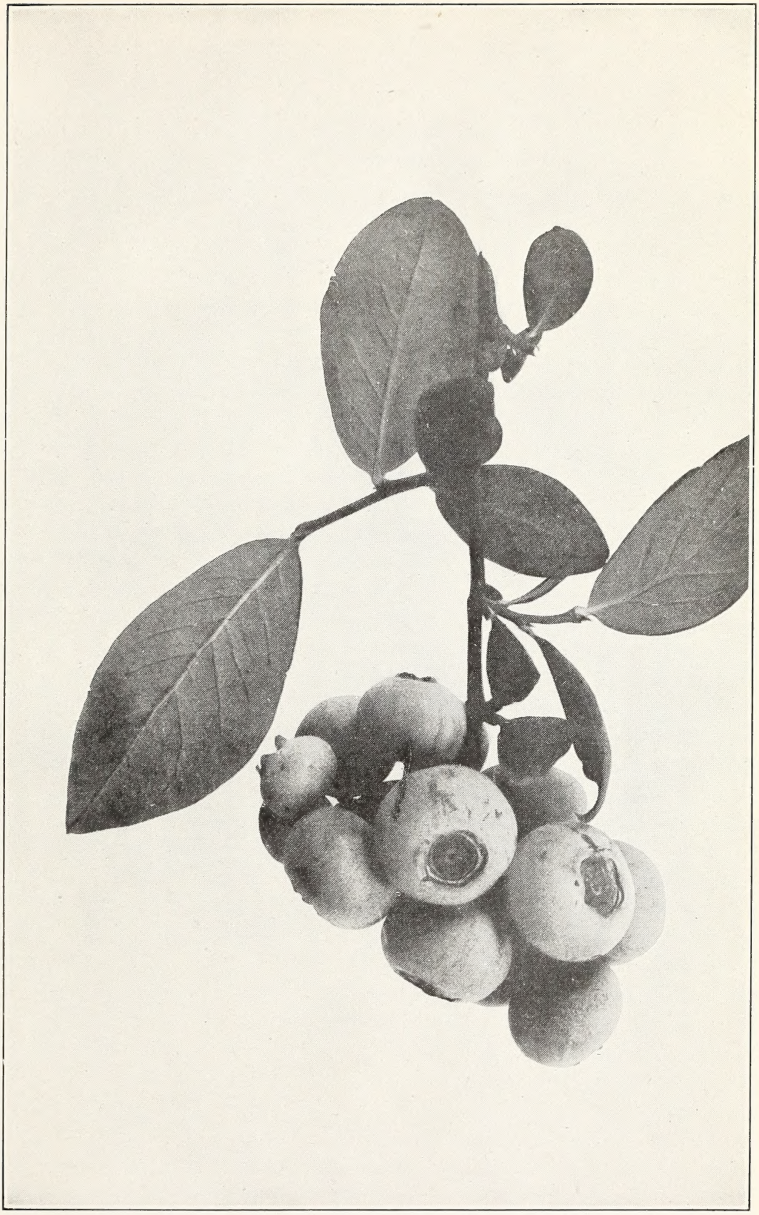
The mellowing and good aeration accomplished in the white, sandy soil with the spring-tooth harrow is well shown in this figure. Shallow cultivation is at most times desirable in blueberry plantations, for the roots of the plants tend to make their principal development within a foot of the surface. The plants here shown are at 4-foot intervals in rows 8 feet apart.

FIVE-YEAR-OLD BLUEBERRY HYBRID.

This plant is a triple hybrid. One of the parents was a wild highbush blueberry from New Jersey, known as Rubel, with very large berries. The other parent was a hybrid bred from two large-berried wild plants from Greenfield, N. H., one of them a lowbush blueberry called Russell, the other a highbush blueberry named Brooks. The hybrid combines the sweetness of Russell, the delicious flavor of Brooks, and the large berry of Rubel. From its Russell grandparent it has inherited also medium earliness of fruiting and medium stature, being about 3 feet high when photographed.

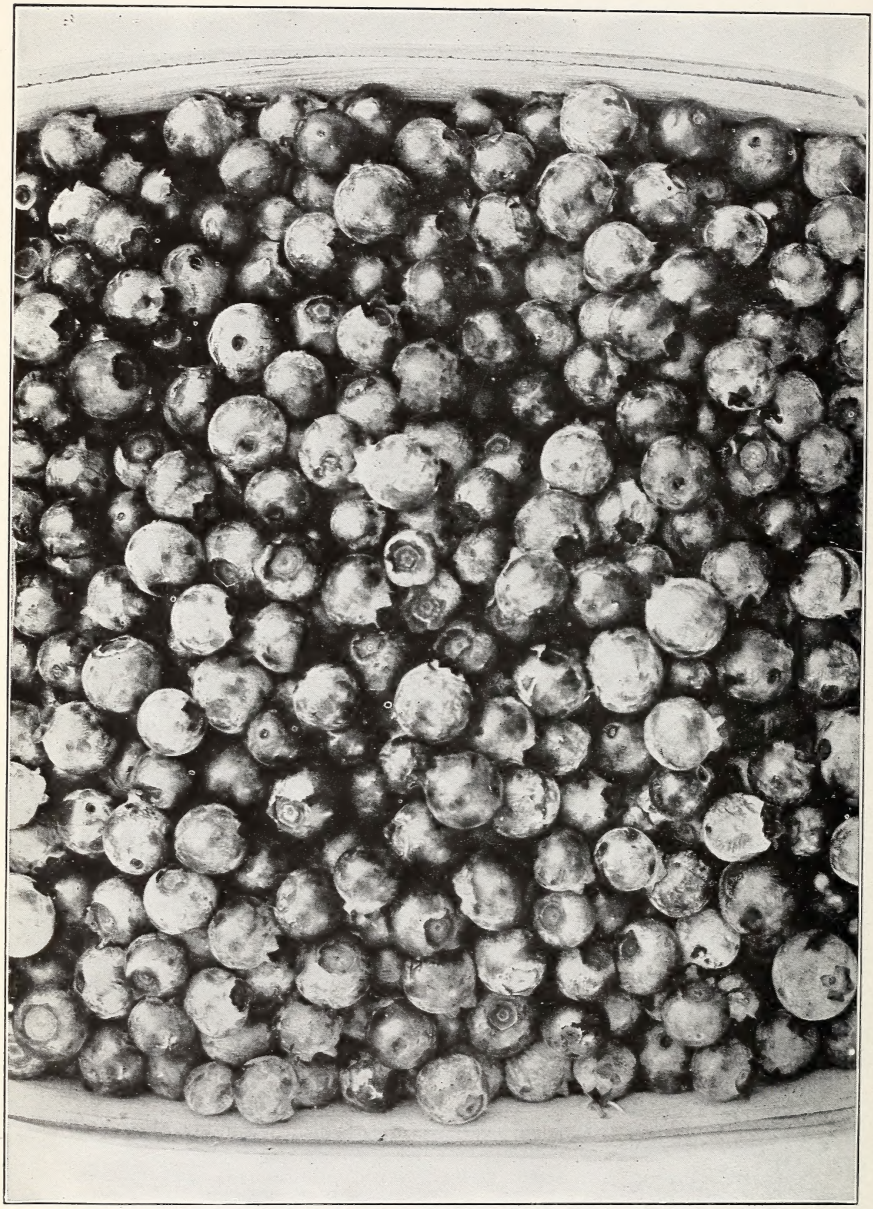
HANDSOME CLUSTER OF BLUEBERRIES FROM A REJECTED HYBRID.

Among the thousands of hybrids fruited at Whitesbog, N. J., hundreds produce berries as large and as handsome as these, yet although they are superior to all wild berries except the very best they are not regarded as of sufficiently high quality to merit selection and propagation when judged from the high standard set for hybrid blueberries. However, from unselected hybrid bushes of this class a yield of berries was obtained in 1919 at the rate of 96 bushels per acre. They sold at a little over $10 a bushel, bringing gross receipts at the rate of $966 per acre. In 1920 this planting yielded at the rate of 117 bushels per acre, which sold at a little less than $11 a bushel, yielding gross receipts at the rate of $1,280 per acre.



CLUSTER OF BLUEBERRIES FROM A SELECTED HYBRID.

From a photograph, taken on July 17, 1918, of a cluster of berries from a cultivated variety named Katharine. This is a selected hybrid, produced at Washington, D. C., and fruited at Whitesbog, N. J. Its parents are the Brooks blueberry, from Greenfield, N. H., and the Sooy blueberry, from Browns Mills, N. J., both of them wild plants of the high-bush type. (Natural size.)



THE ORDINARY WILD BLUEBERRY OF NEW JERSEY.

From a photograph, natural size, of a quart box of wild New Jersey blueberries, rather better than the average. It was taken for the purpose of comparison with the selected hybrid blueberries shown in Plate XXIX.

FRUIT OF THE KATHARINE BLUEBERRY, A SELECTED HYBRID.

The illustration shows, in its natural size, a quart box of hybrid blueberries of the same variety illustrated in Plate XXVII. The photograph represents the average product of the bush, for it was taken from a clean picking, including the small berries as well as the large ones.